Deliverable D5.3 - Intermediate Report on 5G Testbed Integration and EVI Deployment Guidelines

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Abstract

This document presents an intermediary report about the ongoing tasks of the work package "5G Infrastructure Integration and Experimentation Enablement" (WP5).

The primary goal of this work package is to integrate all the components of the 5GINFIRE platform to create the envisaged architecture that will support the deployment and use of Experimental Vertical Instances (EVIs), that is a is a composition of several virtual functions spanning all layers from application and services to networking. Two EVIs are in the initial focus of the 5GINFIRE: automotive and smart cities. These are the two first ones that are being deployed to showcase the 5GINFIRE platform.

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Impressum

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- Task 5.1: Overall 5GinFIRE platform integration and coordination
- Task 5.2: Enabling 5G Automotive Vertical Testbed for VxF Experimentation and other EVIs
- Task 5.3: FIRE testbeds as deployment platform

Document title: Deliverable D5.3 - Intermediate Report on 5G Testbed Integration and EVI Deployment Guidelines

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Executive summary

The deliverable 5.3 provides a first version of the Report on 5G Testbed Integration and EVI Deployment Guidelines. It is therefore positioned as an Intermediate Report on Fifth Generation of Mobile Networks (5G) Testbed Integration and Experimental Vertical Instances (EVI) Deployment Guidelines that drives further integration work in WP5. This document also presents a joint result from the implementation work in WP4 and WP3, based on the requirements and specification on WP2, towards a deployable platform for Virtual Network and Vertical Functions (VxFs).

The main outcome is a preliminary guideline of the 5GinFIRE platform. This provides a guide into the main 5GinFIRE platform components and the interaction with the infrastructure provided by stakeholders such as UNIVBRIS, TID, UC3M, UoP and ITAv. D5.3 not only includes the specification of high-level interfaces to the 5GinFIRE platform but further describes the integration among all 5GinFIRE components providing the main points for the realization of WP2, WP3 and WP4. D5.3 further provides information on relevant functionalities and capabilities available at 5GinFIRE platform.

The methodology driving the guideline starts with the main concept that underline the 5GinFIRE platform, most important related to user functionalities and the emerging EVIs for 5G networks. The 5GinFIRE architecture and its main components are presented including a brief overview of the 5GinFIRE Portal, the Management and Orchestration (MANO) platform, Future Internet Research and Experimentation (FIRE) technology convergence, 5G in A Box capability and EVIs. Then the EVI deployment procedure is highlighted. Following, the concise platform's benefits for users and service providers are formulated through two use cases in the context of 5G Automotive and Smart City verticals. These use cases as well as the insights provided by our design and specification performed in D2.1 [1] are used to derive requirements for the 5GinFIRE platform as well as the infrastructure. With this, D5.3 not only provides the intermediate reports on 5G testbed integration as concise outcome, it also briefly describes the next steps to the final and complete ecosystem integration.

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Table of Contents

Abbreviations

5G: Fifth Generation of Mobile Networks

5GINFIRE: Evolving FIRE into a 5G-Oriented Experimental Playground for Vertical Industries

AAA: Authentication, Authorization, and Accounting

AAI: Authentication and Authorization Infrastructure

BiO: Bristol Is Open

CEaaS: City Experimentation as a Service

EVI: Experimental Vertical Instance

FIRE: Future Internet Research and Experimentation

IoT: Internet of Things

MANO: Management and Orchestration

MEC: Mobile Edge Computing

NFV: Networking Function Virtualization

NS: Network Service

NSD: Network Service Descriptor

OBD: On-Board Diagnosis

OBU: On-Board Unit

OSM: Open Source MANO

PNF: Physical Network Function

R&D: Research and Development

RSPEC: Resource Specification

RSU: Roadside Unit

SDN: Software Defined Networking

SIP: Session Initiation Protocol

SBC: Single-Board Computer

SFA: Slice-Based Federation Architecture

TOSCA: Topology and Orchestration Specification for Cloud Applications

UGW: Unified Gateway

UE: User Equipment

V2X: Vehicle-to-Everything

VIM: Virtualized Infrastructure Manager

VLAN: Virtual Local Area Network

VNF: Virtual Network Function

VxF: Virtual Network and Vertical Functions

1 Introduction

This document presents an intermediary report about the ongoing tasks of the work package "5G Infrastructure Integration and Experimentation Enablement" (WP5).

The primary goal of this work package is to integrate all the components of the 5GINFIRE platform to create the envisaged architecture that will support the deployment and use of Experimental Vertical Instances (EVIs). An EVI is a composition of several virtual functions spanning all layers from application and services to networking. The 5GINFIRE portal will be used by experimenters to instantiate new and existing EVIs. The 5GINFIRE Management and Orchestration (MANO) platform is responsible for orchestrating the EVI inside the 5GINFIRE testbed.

Two EVIs are in the initial focus of the 5GINFIRE: automotive and smart cities. These EVIs are the first ones that are being deployed to showcase the 5GINFIRE platform. Experiments will be able to use these EVIs as a starting point to test applications, services, and solutions regarding these areas.

This document is organized as follows: Section 2 presents an overview of the 5GINFIRE platform and its main components. Section 3 shows the EVI deployment procedure using the 5GINFIRE portal. Section 4 details the automotive and smart city EVIS that are being integrated into the 5GINFIRE platform. Section 5 shows the next actions related to the EVI integration and exploitation using the 5GINFIRE platform, and finally, Section 6 concludes this document.

2 Overview of the 5GINFIRE platform

The next generation of International Mobile Telecommunication system, a.k.a Fifth Generation of Mobile Networks (5G), will use the concept of the network softwarization to provide several network slices on top of the same infrastructure. Each slice will support applications with different requirements such as low latency, reliability, and massive broadband. These diverse applications will focus on different markets called verticals.

A network slice is end-to-end logical mobile network, and one of its components is a set of combined Virtual Functions of Network and Verticals (VxFs) deployed on different cloud infrastructures of an operator.

The 5GINFIRE platform is an experimental playground where different actors of the telecommunication ecosystem will have an infrastructure available to create instances of verticals. Theseb instances will use the concept of a standardized Networking Function Virtualization (NFV) distributed in the 5GINFIRE facilities.

Figure 1 presents the overall vision of the 5GINFIRE experimental approach. The 5GINFIRE portal and middleware will provide to experimenters an environment to compose different services by composing VxFs. The portal also will have a repository of VxFs and Network Services Descriptors (NSD) allowing the experiment to reuse VxFs and NSDs defined by others.

Based on an open source MANO, called Open Source MANO (OSM) [2], which provides a software implementation of a MANO stack aligned with the ETSI NFV reference architecture [3], the cloud infrastructure will be orchestrated to deploy the VxFs and create an instance of a vertical based on specific requirements. In this context, it will be possible to experiment scenarios where some VxFs are close to the user, in a Mobile Edge Computing (MEC) scenario and others are in the operator core cloud.

Inside 5GINFIRE, functions of two verticals will be created as a demonstration of the capabilities of the facilities: automotive and smart cities.

The 5GINFIRE platform aims to reuse Future Internet Research and Experimentation (FIRE) testbeds. The first step for this integration is related to Authentication, Authorization, and Accounting (AAA), to expose 5GINFIRE portal to other FIRE Testbeds and to create a Resource Specification (RSPEC) by the 5GFINFIRE portal, that would be consumed by FIRE based testbeds.

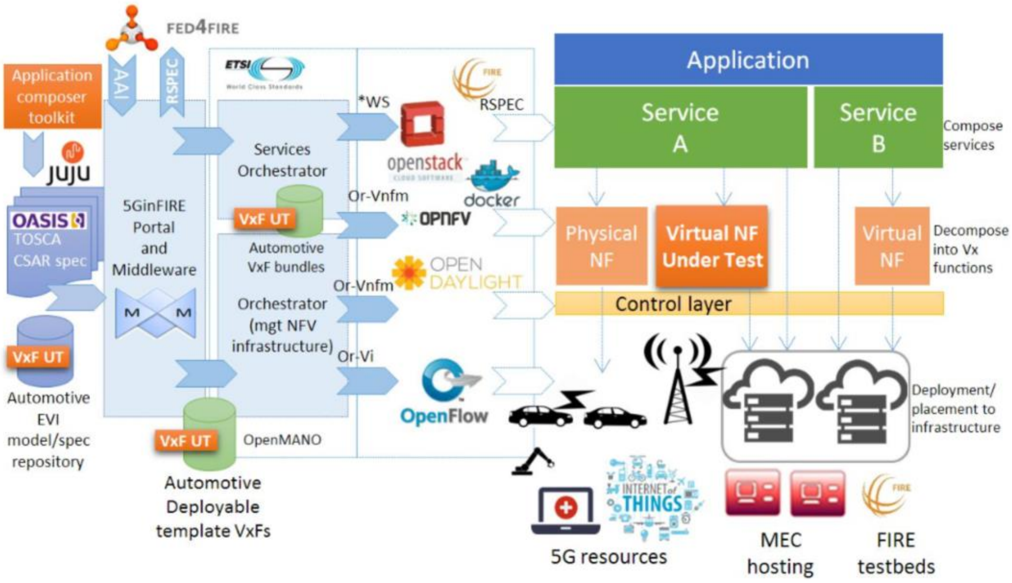

Figure 1 - 5GinFIRE Experimentation Workflow, Technologies and Infrastructures

2.1 Architecture

5GinFIRE is building the Open5G-NFV ecosystem of experimental facilities capable of supporting verticals such as the 5G automotive use cases and Smart City Safety uses cases described in Section 4. In order the expose the 5GinFIRE platform for experimentation, an integration methodology is being followed according to Figure 2. The 5GINFIRE reference architecture [1] is flexible to integrate new facilities and functionality into the ecosystem without compromising openness and compatibility standards. From this perspective, the experience gathered from expanding the 5GinFIRE ecosystem transformed into guidelines for experimenters, constitutes a use case on its own.

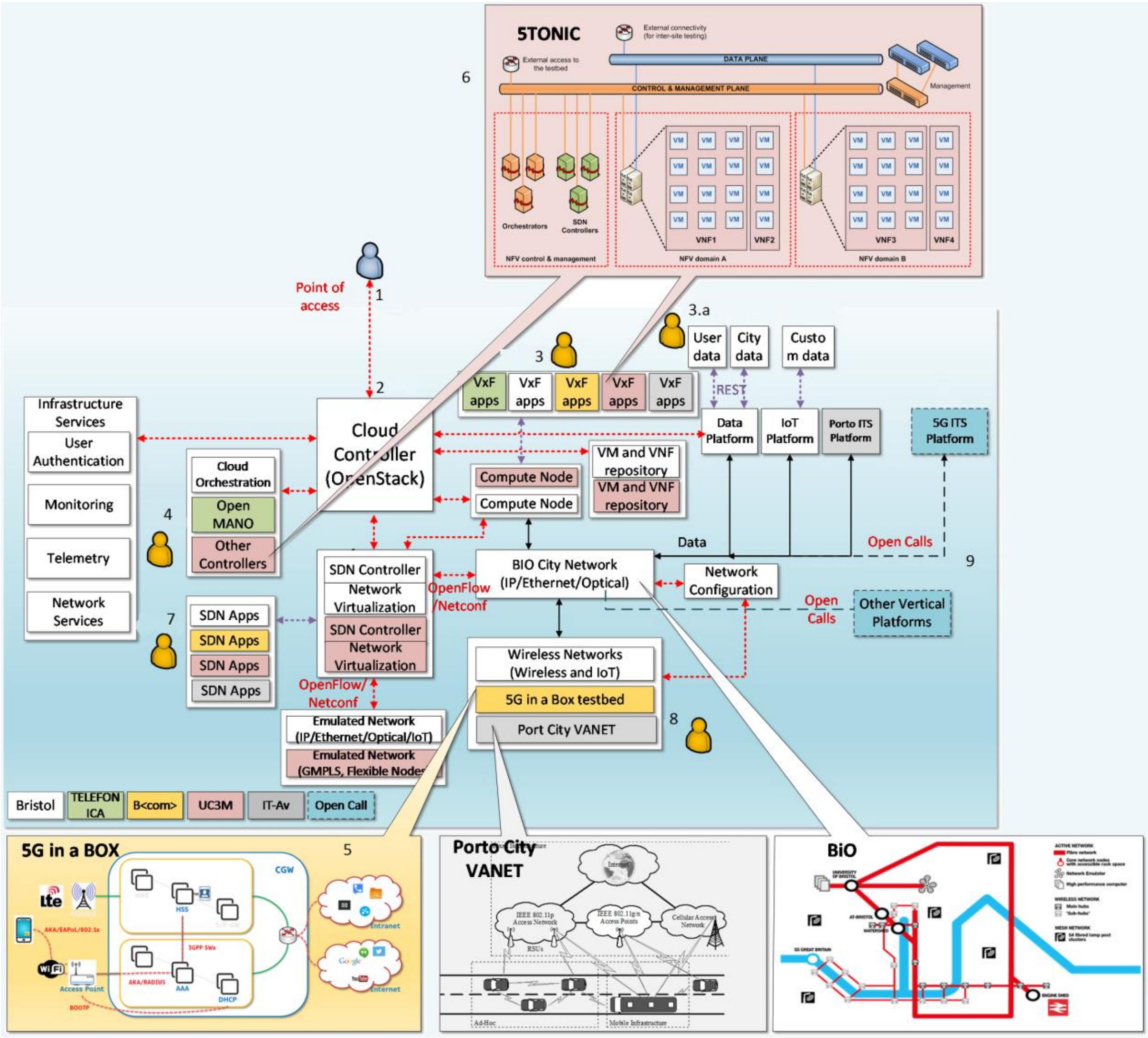

Figure 2 - Methodology of 5GinFIRE Testbed Integration

The overall functional description of the methodology depicted in Figure 2 is described as follows.

1. 5GinFIRE platform access: users have high level and integrated access to available services and interfaces through the 5GinFIRE Portal hosted at UoP.
2. Cloud access: using the 5GinFIRE Portal and the APIs the experimenter has access to multi-site NFVI located, at this moment, in UNIVBRIS and Bristol is Open (BiO), ITAv and 5TONIC to deploy network function images and control them.
3. VxF catalogue access: users have also access to a VxF catalogues, named EVIs where templates and instantiating functionality are available.
    a. Data access: data can be generated from the infrastructure.
4. VxF access: users can define the lifecycle of the virtual machines/functions in the network.
5. 5G-In-A-Box platform: WiFi/LTE 5G in a box platform offering fast deployment for indoor and outdoor environments via Physical Network Function (PNF) and Virtual

Network Function (VNF) based on unified access between 3GPP and non-3GPP radio access networks is available.

6. Software Defined Networking (SDN) application access: SDN applications with defined REST interfaces will be used for software defined networking.
7. Infrastructure access: users can deploy and control their hardware in city or emulated network facilities.
8. New vertical: other vertical platforms and extension from the existing ones are enabled.

The next sections present an overall overview of each building block from the experimenter's perspective highlighting their principal capabilities and functionalities.

2.2 5GinFIRE Portal

The 5GinFIRE Portal is the central point where users will submit requests for experiments as well as expose Network Service Descriptors and Virtual Functions Descriptors. The portal and its associated middleware is responsible for services like:

- Offer an endpoint where experimentation requests will be accepted.
- End users can subscribe, manage experiments, browse the repository, monitor experiment results, etc.
- Access to the 5GInFIRE repository of VxFs metadata and templates, categorized in verticals
- Services that will allow administrators and developers, using the DevOps paradigm, to manage the offered 5GInFIRE platform as well as to manage the repository
- Support, not only for experimenters, but also for VxF developers (users that want to maintain and offer their VxFs through our 5GInFIRE repository).
- Authentication Authorization Infrastructure (AAI) compatible with other FIRE testbeds via the Fed4FIRE AAI technology, thus accepting seamlessly FIRE users, allowing the creation of federated experiments, and facilitating integration of existing FIRE facilities
- Visibility of the 5GInFIRE repository as an RSPEC, therefore having the entire infrastructure browsable by other FIRE catalogs like the Fed4FIRE portal.
- Model-to-model transformations that will provide the ability to automate the transformation of the experimentation and service requests into actions to be performed by the Services and Management orchestrators of the MANO layer.

The initial design and first version implementation are described in deliverable D3.1 [4], while the initial requirements where described in D2.1 [1] The portal is available at https://portal.5ginfire.eu

2.3 Experimental Instances of Verticals - EVIs

5GinFire is addressing different types of users for EVI:

- Experimenters who wants to use the automotive and smart city EVI environment as it is, taking advantage of the provided EVI features such as SDN, NFV and VxFs to test vertical applications

- Open source developers who wants to provide new functionality that may be integrated in the lifecycle management of infrastructure components.

For both categories, the user first step is to refer to the Section 2.2 (5GinFIRE Portal) and then to apply the procedure described in the Section 3 (EVI Deployment Procedure).

For the first category and the users who wants to perform testing on testbed site, please refer in detail to the two testbeds with outdoor facilities:

- "Bristol is Open as a Playground for verticals (BiO)".
- "Automotive EVI Environment (ITAv)".

For the second category and the users who want to deploy a VxF, please refer in detail to Section3. This section will particularly detail the requirements for a VxF developer who will need to specify a Network Scenario (how to chain the VxF with other functions) and a Network Service Descriptor to deploy the VxF through OSM in 5GinFire environment.

There is a last possibility with a user who wants to deploy an ad hoc outdoor network. In such a case, he could take benefit of "5G-In-A-Box Functionalities" which can be considered as a PNF described in Section 2.6.

2.4 The 5GinFIRE MANO platform

The 5GinFIRE MANO platform is the system that enables the management and orchestration of Network Services (NS), potentially composed of multiple VxFs, across the experimental infrastructures provided by 5GinFIRE partners, hereafter referred to as 5GinFIRE testbed providers. To fulfill this objective, the platform offers a northbound interface to the 5GinFIRE portal, enabling the operations that are needed to support the execution of experiments (e.g., onboarding a NS and a VxF). A simplified overview of the 5GinFIRE MANO platform is depicted in Figure 3.

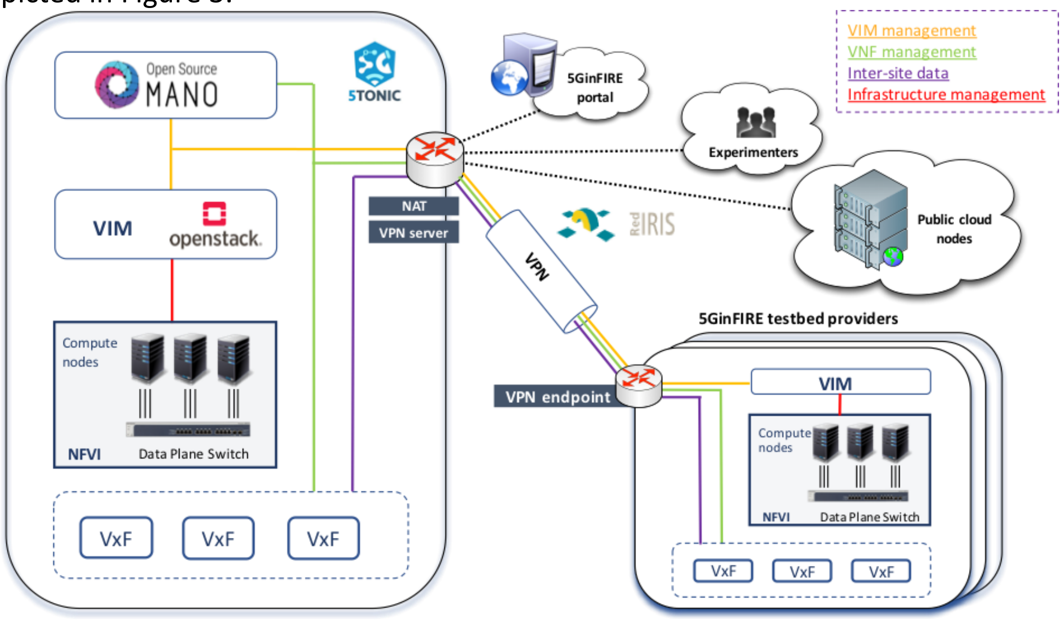

Figure 3 - Overview of the 5GinFIRE MANO platform

The platform is based on the ETSI-hosted OSM project [2], which has been adopted by 5GinFIRE to provide the functionalities of a NFV orchestrator, supporting the management and coordination of computing, storage and network resources at the diverse experimental infrastructures, as well as the lifecycle management of network services. With this purpose, the OSM stack interacts with the Virtualized Infrastructure Managers (VIM) deployed by 5GinFIRE testbed providers.

There are currently three 5GinFIRE testbed providers that have deployed the components and functionalities required to operate the 5GinFIRE MANO platform, making available the following experimental infrastructures: (a) an infrastructure at the global 5G Telefonica Open Innovation Laboratory (5TONIC) [5] , made available by TID (founding member of 5TONIC) and UC3M (member of 5TONIC); (b) an infrastructure located at ITAv; and (c) an infrastructure made available through a collaborative agreement by UNIVBRIS and BIO.

According to the agreements made by project partners, the first stable version of the 5GinFIRE MANO platform is based on OSM Release TWO, being the OSM stack hosted at 5TONIC. Inter-site communications among 5GinIFIRE testbed providers are enabled by an overlay network architecture based on VPNs (to simplify operations, the primary VPN server is hosted at the same site as the MANO stack, i.e. 5TONIC). This overlay network enables the establishment of the following types of data exchanges: (a) communications between the OSM stack and the VIMs and SDN controllers; (b) communications between the OSM stack and the VxFs, to support their configuration; (c) inter-site data communications among VxFs.

The technical solution adopted by 5GinIFIRE also supports the flexible incorporation of other sites (e.g., coming from the Open Call process of 5GinFIRE), as long as they support a compliant VIM and they set up the appropriate inter-site connection mechanisms. It also supports the integration with the public cloud, with specific VIM plugins available from Release TWO of OSM[1]. A comprehensive description of the 5GinFIRE MANO platform, along with the requirements that must be met to connect to it, can be found in [6]. For the sake of reference, Table 1 summarizes the main NFV components and infrastructure that, at the time of writing, have been made available for experimentation by 5GinFIRE testbed providers.

Table 1 - Summary of NFV components and infrastructure.

Testbed Provider	NFV components and infrastructure
5TONIC	NFVO: based on OSM Release TWO (running in virtual machine using a server computer with 16 cores, 128 GB RAM, 2 TB NLSAS hard drive and a network card with 4 GbE ports and DPDK support). VIM: two instances of OpenStack Ocata [7], each controlling a separate NFVI (referred to as 5GinFIRE NFVI and IMDEA NFVI in this table). • The first one runs in a server computer (6 cores, 32GB of memory, 2TB NLSAS and a network card with four GbE ports and DPDK support). • The second one runs as a virtual machine in the same server computer as the OSM stack.

[1] OSM Release TWO supports multiple VIMs through a plugin model, including OpenVIM, OpenStack, VMWare vCloud Director and Amazon Web Services Elastic Compute Cloud.

Testbed Provider	NFV components and infrastructure
	5GinFIRE NFVI: • 3x server computers (each with 6 cores, 32GB of memory, 2TB NLSAS and a network card with four GbE ports and DPDK support) • Interconnected by a GbE data-plane switch. IMDEA NFVI: • 2x high-profile servers (each equipped with 8 cores in a NUMA architecture, 128GB RDIMM RAM, 4TB SAS and 8 10Gbps Ethernet optical transceivers with SR-IOV capabilities). • Interconnected by a 24-port 10Gbps Ethernet switch.
ITAv	VIM: based on OpenStack Ocata. NFVI: • 1x server computer: 24 cores, 192GB memory, 4 x 1Gbps interfaces (passthrough, DPDK and SR-IOV), 2 x 1TB SAS3 hard drives. • 1x server computer: 16 cores, 256 GB memory, 4 x 1Gbps interfaces (passthrough), 2 x 1TB SAS2 hard drives. • 1x 24-port 1Gbps switch, interconnecting the infrastructure.
UNIVBRIS& BiO	VIM: based on OpenStack Ocata. NFVI: • 1 server computer: 2x8 core 16 threads CPU 2.4 GHz, 32GB RAM, Dual RAID 1 900 GB HDs. • 1 server computer: 2x8 core 16 threads CPU 2.4 GHz, 16GB RAM, 900 GB storage. • 1x MVB NEC optical switch, 1x ENS NEC optical switch.

2.5 FIRE Technological Convergence Capability in 5GinFIRE

The FIRE [8] initiative aims to provide experimental facilities to support research and innovation in domains such as Smart Cities, Internet of Things (IoT) and networking [9]. These facilities are deployed around the world in Europe, United States, Brazil, Korea and Japan.

Several of these facilities are federated under the project FED4FIRE+ [10] FED4FIRE+ provides several tools related to the life cycle of experiments [11]. One of these tools, JFED [12], provides a user interface where the experimenter can graphically compose an experiment selecting resources from different facilities.

This notion is related to a 5G network slice, in fact, FED4FIRE+ uses an approach called Slice-Based Federation Architecture (SFA) [13] for resource discovery and provisioning. While the experiment is composed, a RSPEC [14] is created. This RSPEC is used by a FED4FIRE+ compliant facility to provision and reserve the resources that will be required in the experiment.

While 5G network Slice is being heavily influenced by the industry, the GENI/FIRE based network slice was created by the community related to future Internet research.

A network slice that puts together FIRE and 5G based facilities will be closer to a real scenario where FIRE based facilities may play the role of the edge of the network, and the 5GINFIRE facilities may play the role of the operator cloud.

The synergies between the FIRE related projects and the 5GINFIRE facility can provide a holistic experimental environment suitable to experiment the vertical applications scenarios. This proposal focuses on FUTEBOL and 5GINFIRE facilities.

As a first example of this integration, 5GINFIRE can act as a repository of VxFs to any other FIRE related projects. In this scenario, an experimenter of a FIRE related project will be able to create in a FIRE compliant facility an experiment that uses a group of VNFs grouped in a Network Service Descriptor (NSD). On the experiment creation time the NSDs and VxFs, stored in the 5GINFIRE will be consumed by the FIRE facility, and the NSD will be deployed on it.

The FIRE facility, to accomplish the first scenario, will need to communicate with the 5GINFIRE portal back-end. This back-end offers an API that exposes all the services provided by 5GINFIRE. This API is already used by the 5GINFIRE portal front-end. The integration between a FIRE compliant facility and 5GINFIRE will be done using this API. A software component needs to be created to consume 5GINFIRE services and interact with the FIRE facility control framework. The 5GINFIRE API has authentication and authorization services, and this component will be responsible for authenticating each FIRE facility before accessing the 5GINFIRE services.

To use VxFs and NSDs provided by 5GINFIRE inside FIRE facilities, it will be necessary to convert YAML files used to describe VxFs and NSDs to the RSPEC, that in general is used by JFED in FED4FIRE+ compliant facilities. Using the RSPEC, the FIRE facility will provision resources.

As a second example of the integration between a FIRE facility and 5GINFIRE is a junction between both facilities to create a “5G slice” to be used by experimenters.

In this second scenario, an experimenter of a FIRE facility will create an experiment that uses a network slice that is deployed at both FIRE and 5GINFIRE facilities. This slice can use resources, such as sensors, available in the FIRE compliant facility. In this case, the FIRE facility will play the role of the Mobile Edge Computing (MEC) where VxFs will be deployed. The 5GINFIRE facility will play the role of the telecom operator core, where other related VxFs will also be deployed to support this service. The NSD, based on industry standards, available in the 5INFIRE facility will have the constituent VNFs specified accordingly to this service requirement. With this approach, it will be possible to create an experiment where the services in the FIRE facility will be closer to the user and may offer a situation where the experiment requires lower latencies from the 5G slice and using the FIRE facility as the MEC.

To create the 5G slice, as described in the second scenario, it will be necessary integration between a FIRE compliant facility and 5GINFIRE not only in the control and management plans but also in the data plane.

The first scenario is ready to be done as the 5GINFIRE portal back-end is already deployed. The second scenario takes into consideration a deeper integration, and it is necessary a joint work between 5GINFIRE and a FIRE facility to conduct its deployment. This subject can be explored in the 5GINFIRE open calls.

2.6 5G-In-A-Box Functionalities

A 5g-In-A-box capability will be provided. It will provide connectivity (IP) to different UEs through Wi-Fi and/or 4G radio accesses. This capability will be provided by a UGW in charge to manage authentication, UEs sessions and end to end connectivity (from UEs to internet and/or Application Servers).

This UGW will be provided in two different modes:

- as a PNF hardware servers pre-installed (including different VNFs) and integrated with the radio Access Points (deployed in UNIVBRIS site).
- as a set of Virtual Network Functions which can be deployed on an infrastructure datacenter on an openstack instance. This deployment will be handled by OSM orchestrator.

Thanks to this IP Connectivity provided to Applications, the Application providers (e.g. OpenCall) can provide features to the connected User Equipment (UE) using different protocols on top of this IP Connectivity.

Examples applications are:

- web server (http), ftp, other application protocols),
- Session Initiation Protocol (SIP) phone server (tcp/sip, udp/rtp protocols for instance),
- video streaming or others.

It can be used also by other specific applications using information from the connected UE (localization information, information from UE camera, etc.) to aggregate them and/or provide contextual service to the users.

The UGW does not provide any dedicated or specific APIs for experimenters. It provides connectivity management between UEs and radio access infrastructure.

2.7 Bristol is Open as a Playground for verticals

BIO aims to create a living lab Research and Development (R&D) Testbed targeting City-driven digital innovation as a City Experimentation as a Service (CEaaS). It provides a managed multi-tenancy platform for the development and testing of new solutions for information and communication infrastructure, and thus forms the core ICT enabling platform for Future Cities agenda. BIO integrates SDN enabled optical, wireless, sensor mesh and computing resources to provide a unique open and programmable communication service platform in the centre of Bristol.

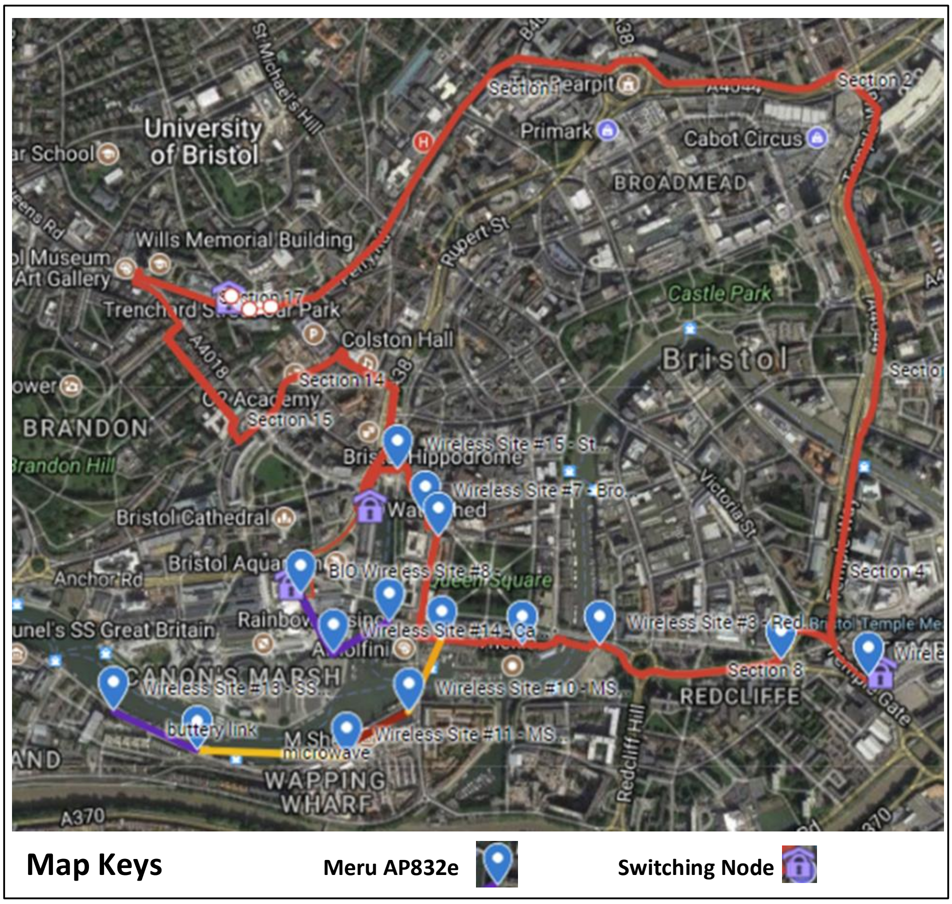

Figure 4 - BIO wireless and fiber connectivity

2.7.1 Wireless connectivity

BIO's wireless infrastructure specifically includes a wireless network hub across multiple locations within Bristol City Centre, as seen in Figure 4 above. The cell radio technology offers a wireless connectivity solution using SDN enabled Wi-Fi technologies with enhanced millimeter backhaul and direct connections to the optical network. The Wi-Fi access point devices utilized are the Meru AP832e. Specifications on the devices can be found below.

Meru AP832e specifications

- Max throughput is 1M in current configuration
- Supported 2.4 GHz (TurboQAM Mode) and 5.x GHz for dual-band, dual- radio operation, data rate up to 1.9 Gbps
- SSIDs can be setup across multiple access points for individual projects
- For full technical specification please see: https://meruconnect.com/meru-networks-ap832e.html#product_tabs_techs

2.7.2 Switching technologies

BIO currently use the following switches in four switching nodes in the Bristol city center:

- NEC PF5459-48XP-4Q fibre switch

- 4x 40Gb Ethernet (QSFP+) 48x 10Gb/1Gb Ethernet (SFP+/SFP)
- There is a 40GHz fibre trunk running between the switching nodes with an additional trunk for out of band management.

2.7.3 Updates to Switching technologies

BIO additionally have additional wireless sites with 10 port Cisco switches by the access points. There are plans to swap these for Brocade ICX 7150 switches. Also Netos SDN controller is deployed within the BIO network.

2.7.4 Server Based Resources

BIO utilizes OpenStack as a cloud controller providing experimenters with an execution environment for experimentation across the BIO platform, and the infrastructure deployed within the city (Wi-Fi/Fibre).

2.7.5 Network Slicing Capabilities

The BIO platform through OpenStack has slicing capabilities using Virtual Local Area Networks (VLANs). The slicing capabilities can be tailored to fulfill experimenters' needs. So, each project/experimentation can be separated through VLANs. BIO has a trunk around the city containing VLANs, these are then split out to individual SSIDs or electrical ports for the experimenters needs. The trunk VLANs terminate in an open stack project but BIO can also route VLANs locally or separately depending on the experimenters needs.

2.7.6 Network Visualization

BIO has several options to provide monitoring and network visualization across the platform and infrastructure to experimenters, to allow for management of experimentation allowing for troubleshooting and diagnosis.

The Meru Wi-Fi controllers deployed across the access points within the city have a proprietary monitoring system, offering centralized management and configuration of all the access points across the city.

BIO also has some network visualization software with multiple capabilities for monitoring performance, and connectivity across the platform and infrastructure. Listed below are the multiple capabilities BIO can offer and the name of the software used.

- Connectivity monitoring-Nagios
- Server performance - Munin
- Network Latency - Smoke Ping
- OpenNMS
- OpenStack monitoring - Jenkins
- Packet Analysis - Wireshark

3 EVI Deployment Procedure

The requirements and the supported actors by the 5GinFIRE portal were presented in the Section 4 of deliverable D2.1 [1]. For clarity we also present them here with less details:

- Experimenter: can upload Experiments in terms of NSDs and request the deployment of an experiment over the 5GinFIRE infrastructure
- VxF Developer: can upload VxF archives
- Testbed provider: can register a target infrastructure
- Services administrator: responsible for the portal management

The portal, as well as the underlying 5GinFIRE services like the MANO stack, needs to support certain functions of the 5GinFIRE experimentation workflow presented in D2.1 [1]. Section 4.3. Figure 5 displays the deployment procedure as described in detail in D2.1 [1].

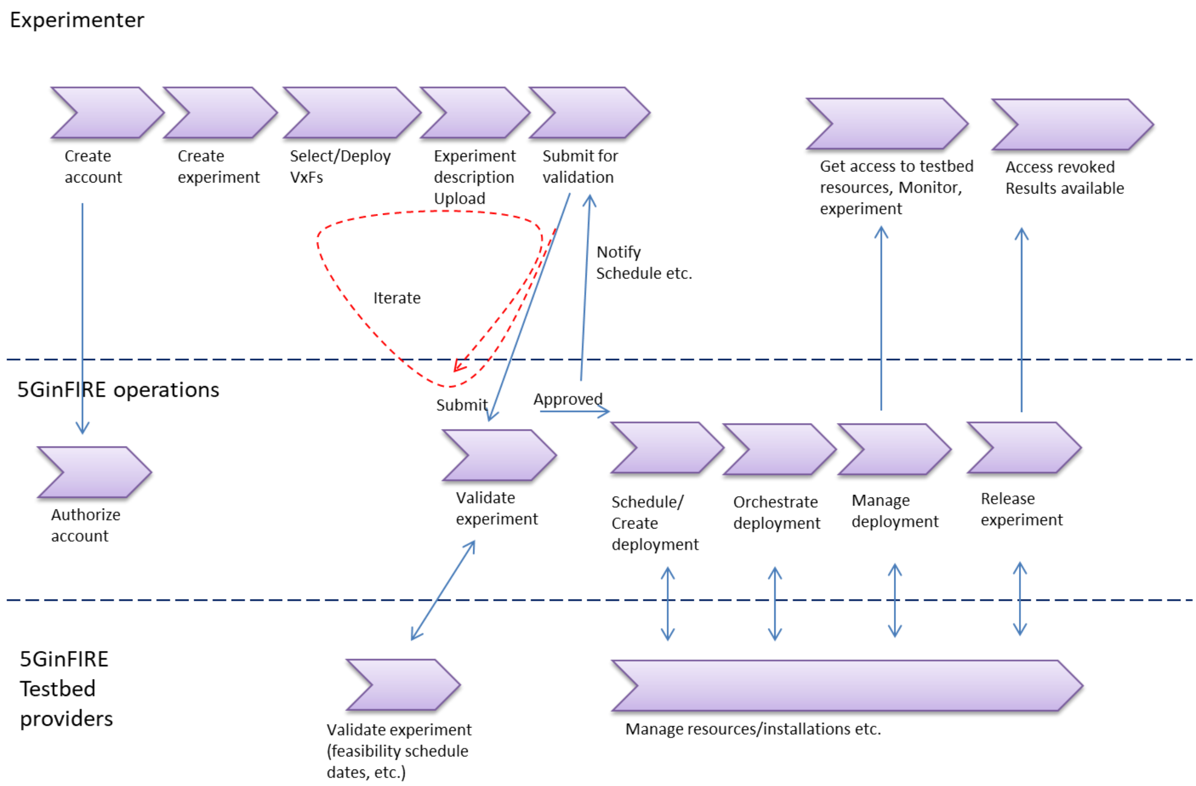

Figure 5 - VxF Deployment Procedure from Experimenter Point of View

Currently and EVI is mapped to a NSD. The 5GINFIRE portal is used to to deploy an EVI. For example, at Figure 6 presents all the necessary fields to define a new deployment. The experimenter can select also the target infrastructure for all or for each individual constituent VxF. The experimenter also provides the necessary information to indicated the period of time when the experiment will run. After providing all this data, the deployment can be requested. This deployment request is sent to the service administrator to be proceeded or to be rejected.

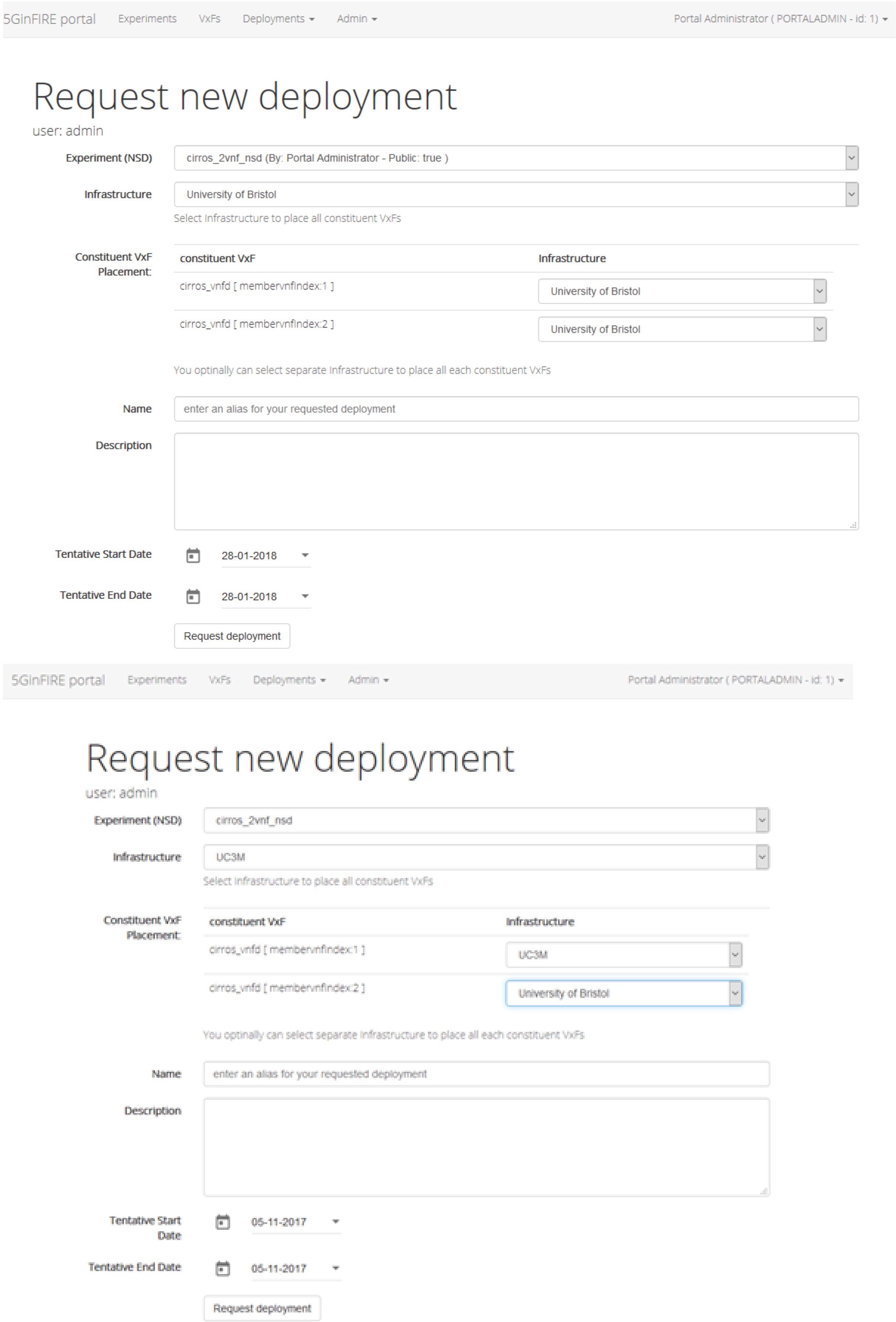

Figure 6 - Experiment deployment creation

As a result of this procedure, and assuming that the experiment is approved, the experiment description is provided to the administrator of the 5GinFIRE MANO platform. It is important to note here that, as the MANO platform is based on OSM [2], NS and VxF descriptors and packages provided by VxF developers and experimenters must conform to the formats supported by OSM (NFV descriptors supported by OSM are based on YANG [15]). Limited support of Topology and Orchestration Specification for Cloud Applications (TOSCA) [16] packages will also be provided through external software that will be linked by the 5GinFIRE portal.

After verifying that the images of the VMs that will be needed to deploy the VNFs are available at the deployment sites provided by 5GinFIRE testbed providers, the administrator of the MANO platform can then deploy the NS. This will be done using the OSM Launchpad, which is the graphical user interface that can be utilized to interact with the run-time system of OSM. Figure 7 shows an example of a network service (cirrosNS) being deployed through the OSM Launchpad. The NS consists of two interconnected VNFs and, as depicted in the Figure 7, the administrator of the MANO platform can choose a specific datacenter for the deployment of each of the VNFs. Besides this, the Launchpad also includes a Dashboard that provides real-time information about the deployed VNFs and NSs. More comprehensive information on the OSM Launchpad can be found in [4].

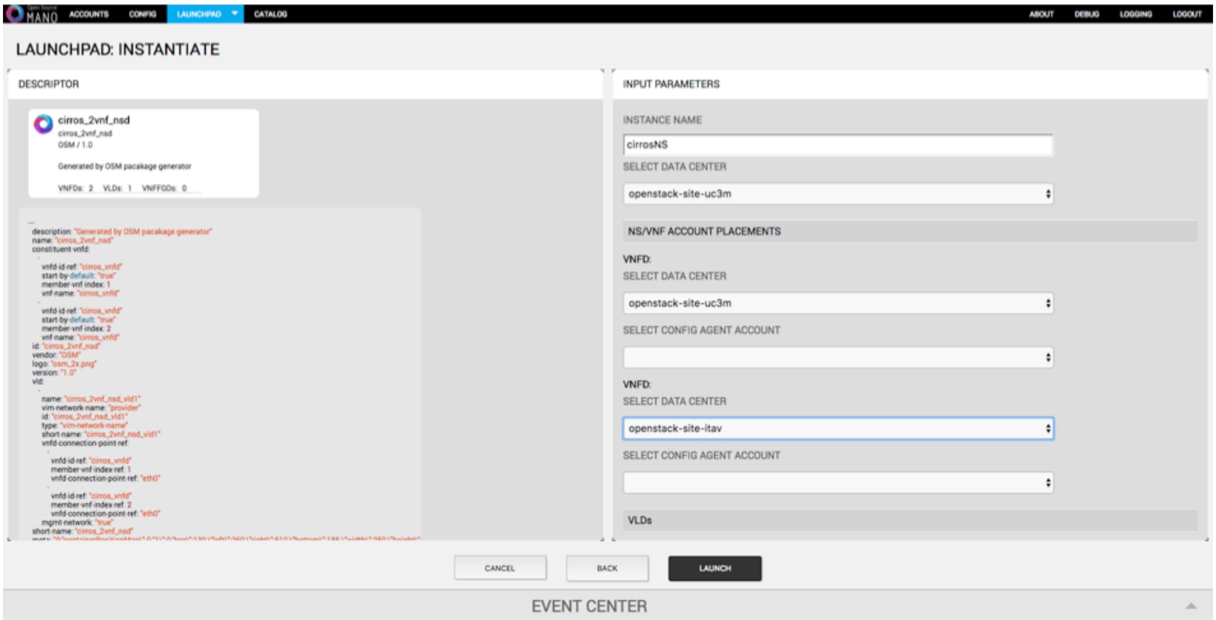

Figure 7 - Example of deployment through the OSM launchpad

After the deployment, experimenters will be able to access their resources under experimentation (i.e., their VNFs) through a VPN service that will be provided at 5TONIC. This service will allow the users to connect to a specific access gateway, from which they will be able to login into the VMs of their VNFs. Details on this mechanism can be found in [1].

4 5GinFIRE Vertical Environments

This section presents the two verticals environments that will allow experimentation regarding automotive and smart city scenarios based on several VNFs.

4.1 Automotive EVI Environment

The vehicular network which serves the base automotive use case consists of On-Board Units (OBUs) in the vehicles and Roadside Units (RSUs) connected to the Internet through an Ethernet interface. The vehicles might connect among each other via standard IEEE 802.11p/ WAVE links, and are connected to the RSUs and the Internet through IEEE 802.11p/ WAVE, IEEE 802.11g/ WiFi or cellular links (see D2.1 [1] for more details on vehicular network connections). Vehicles will have access to its information such as velocity, GPS, camera, and heading. This information will be used by the embedded in-Car Node Processor to take local decisions, and it can also be advertised to the other vehicles (Figure 8). Each car will have access to information from the street and surroundings through embedded car video cameras to/from other vehicles and sensors (crossing roads and traffic lights, cars in the street, adverse conditions in the way, etc.). For the particular case of video streaming, the transcoding process (with VNF video transcoding integrated) will be demanded to reproduce video streaming at any device platforms, assisting the driver on car overtaking situations. This information can be sent and disseminated through vehicles through Dedicated Short Range Communication (DSRC) technology (or to a Wi-Fi station in the street) and then be propagated to the cars in the area. With all this information, each car can access its data, and the one gathered through other cars. Vehicles may use this information to support a variety of use cases, e.g., assisted driving, autonomous driving, collision avoidance, accident detection, emergency messages dissemination, On-Board Diagnosis (OBD) for car self-repairing, etc.

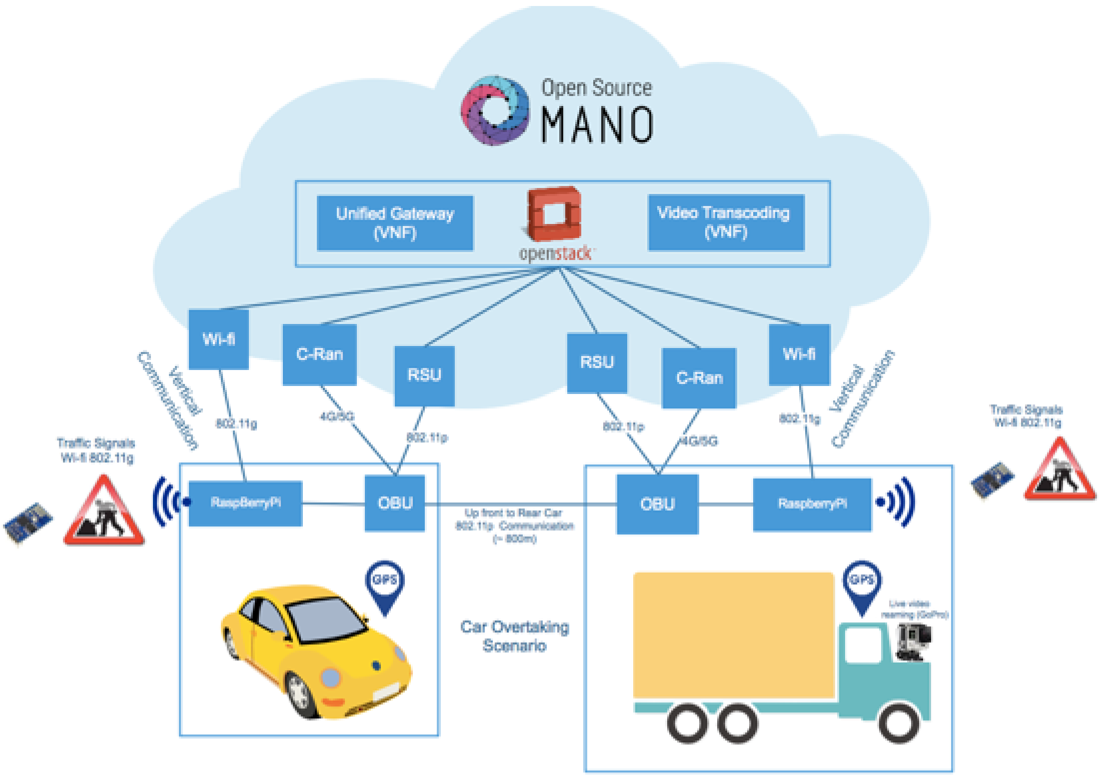

Figure 8 - ITAv Car Overtaking Scenario Overview

Experimenters will have access to real OBUs, RSUs, ESP8266 devices and video cameras, also having the possibility to create and deploy their private VNFs from the 5GinFire portal within the ITAv automotive testbed. Experimenters will have access to a controlled environment in the lab, with the possibility to evaluate and validate their own automotive VNFs services in terms of Vehicle-to-Everything (V2X) communication performance and metrics (e.g., latency vs overhead, throughput vs packet loss, etc.) and test their own automotive VNFs with its diversity of contextual-aware information gathered from extra sensors (traffic signals) and from OBUs internal sensors available (accelerometers, heading, speed, link quality connection, GPS, compass, RSSI, car neighbor's density, etc.). Therefore, other possible VNFs to be included and tested comprise Li-Fi communication between cars, car crash detection and emergency info dissemination, OBD (On-Board Diagnosis for self-repairing), collision avoidance (machine learning) and others.

4.1.1 Available Hardware

- 10 x RSUs/OBUs Single-Board Computer (SBC), DSRC wireless interface (IEEE 802.11p), WiFi interface (IEEE 802.11a/b/g/n), 4G Interface, GPS receiver, antennas for each technology (round antenna is for WiFi and rectangular antenna is for IEEE 802.11p, and higher gains antennas in the RSUs).
- 5 x ESP8266 devices to emulate the traffic signals through Wi-fi client and server-based approach, and 1 x GoPro Hero 4 for video streaming.
- 5 x In-Car Node Processor: 3 ARM RaspberryPi V3 model B, and 2 x node processor x86 with 8 GB RAM and 8 core i7 processors.
- 1 x small cell C-RAN using Band 7 (2.6GHz) for testing purposes (testing license is required "ANACOM/PT"), 2 x Sim Cards 4G/LTE UICC Open Card for subscribers provisioning and 2 x 4G dongles, 1 x OAI EPC running on Xeon-based virtual machine (6 vCPU; RAM 10Gb; Disk 250GB).

4.1.2 Automotive vertical integration

The concrete scenario of the video camera-based for car overtaking is presented in Figure 8. Each vehicle contains an OBU that provides the communication between vehicles and between each vehicle and the infrastructure. The OBU also connects to an Android device, smartphone, through WiFi, that provides visual information for the driver. The vehicle contains a video camera of its front side. This information will be used by the driver to take decisions on driving, and more specifically on overtaking.

The multi-technology communications support might be explored on several situations:

i. The video is streamed from the front vehicle to the rear vehicle through vehicle to vehicle communications, using IEEE 802.11p communication. The OBU in the car receives the video stream and sends it to the visual screen in the car, so that the driver can have real-time access to the visual information of the vehicle.
   ***Status and next steps**: This situation is already horizontally deployed and working without using the VNF video transcoding, since it can only be integrated in the edge network. The next steps envisage the vertical integration to the RSU (802.11p) and C-RAN (4G/5G) at the edge of the infrastructure, which are the case of the vertical integration in following cases.*

ii. If the front and rear cars are in range of road side units (RSUs), the video is streamed to the VNF video transcoding at the edge through the RSUs to reach the rear car. A compromise between video quality streaming vs transcoding speed will be necessary to avoid extra delays.

Status and next steps*: The VNF video transcoding is available on site and is deployed at the edge of the infrastructure. The integration tests have already started and will finalize in February 2018. The next steps envisage the integration with OSM and automatic deployment of the VNF video transcoding from the front car to the rear car through the RSU at the edge of the infrastructure.*

iii. When the cars and RSUs are not in the range of each other, the video is streamed to the VNF video transcoding at the edge of the network using 4G/5G network to communicate between the cars and the edge network. A compromise between video quality streaming vs transcoding speed will be necessary to avoid extra delays.
Status and next steps*: The VNF Unified Gateway will be installed and tested in February 2018, in order to be possible to use the VNF video transcoding from the front car to the rear car passing by the C-Ran at the edge of the infrastructure. The next steps envisage the integration with OSM and automatic deployment of the VNF Unifier Gateway.*

This use case will then be ready to integrate other sources of information, such as traffic signs, and the VNFs and functionalities available and required by the open call projects.

4.2 Smart City Safety EVI Environment

Given the critical importance of security in cities, innovations in the network technologies are increasingly improving the safety of city inhabitants. New services such as remotely connected video systems and automated incident detection allow a quicker response to threats. In this context the Smart City Safety use case improves people's safety by using network softwarization to attend to the real-time requirements and low latency.

This use case looks for monitoring the city with audio and video sensors. These sensors are deployed in a bike helmet and they are attached to a Raspberry PI (RP) that communicates via WiFi to the Cloud or Edge (MEC). The RP sends video and audio to be processed in a datacenter. Using VNF the overall ecosystem should be able to perform audio and video transcoder a long of the network. In addition, audio and video processing using machine learning to detect suspicious activities in the city should take place. Once the suspicious activities have been detected the system is able to notify the security department with the right information. Based on the information the security guards spread in different location will be able to take the right action.

Three 360-degree cameras are attached to three distinct RPs which are attached to three bike helmets respectively. Each RP is connected to a portable battery that can persist for 3 hours. The camera can capture simultaneously audio and video and send to the cloud or MEC. Figure 9 presents a high-level architecture of the smart city scenario.

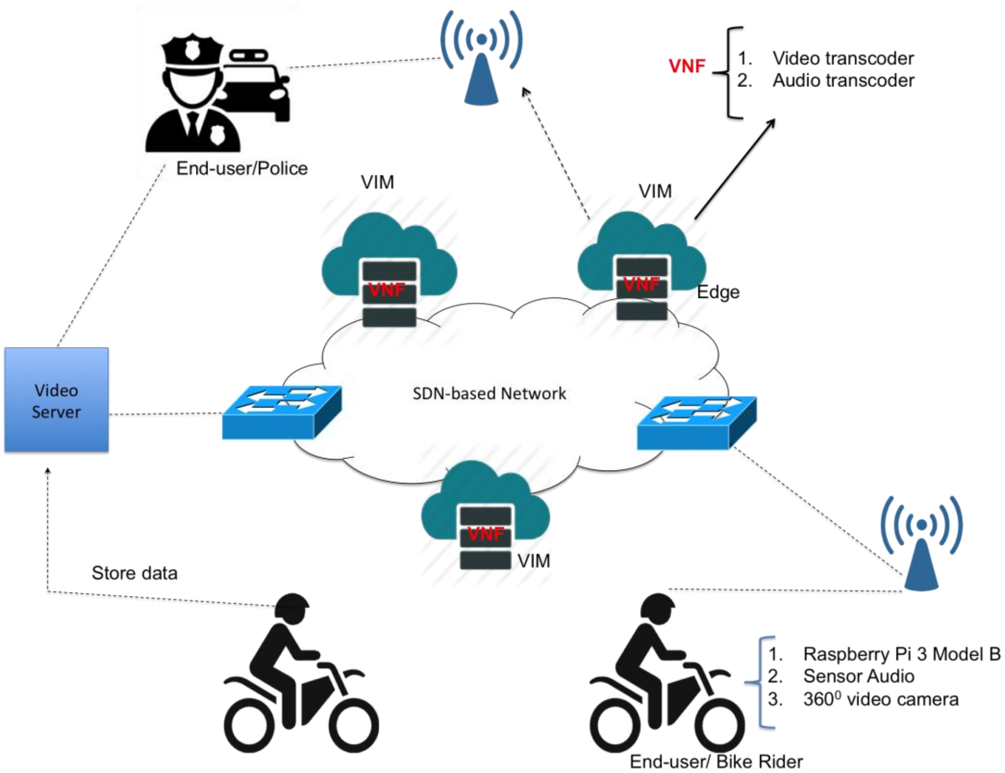

Figure 9 - Smart city safety use case high level architecture and its main building blocks.

Based on this use case the experimenters will be able to instantiate the existing VxFs for Smart City and create new ones to attend the requirements of different smart city environments. In addition, the experimenter will be able to explore the BIO as one of the smart city environments.

The smart city safety use case provides a flexible environment that can easily be extended. Following, some examples of extensions that will be explored:

1. The communication among the 360 cameras and the NFVI currently use Wifi, which is provided by BiO infrastructure. The next step is to add the PNF UGW as part of the use case infrastructure. In this case, all the requests generated into the smart city safety use case should go through the PNF UGW (the core of the network) before reaching the VIM. The PNF UGW provide both Wifi and 4G/5G connectivity.

2. The VNF video transcoder and the face detection algorithm currently are being executed in the cloud. As a next step, the VNF video transcoder and the face detection algorithm will run on the network's edge. In this case in the Raspberry PI or the MEC node.
3. Currently, the smart city safety use case enables to capture video from the environment and to perform face detection. The next step is to allow the capturing of sounds from the environment by using audio sensors attached to the Raspberry PI and identify them. The first approach will be to detect gunshot. To this end, a new VNF audio transcoder will be deployed. As well as an audio processing algorithm.

The smart city safety use case only considers video cameras and audio sensors. The addition of more devices that can also cooperate with the city surveillance is a possible extension that can come as a result of the open call. For example, environmental sensors that allow detecting air contamination in some areas before it spread to the neighbors. The idea is to identify suspicious activities and actuate as soon as possible in real time. Furthermore, all the data generated and stored in the remote cloud can be a subject for future analysis.

5 Testbed Integration and EVI Deployment Roadmap

The goal of this section is to present the roadmap regarding the testbed integration and EVI deployment.

By the end of February 2018, the automotive and smart city EVI Environments will be integrated with the 5GINFIRE testbed, and by March 2018 the 5GNFIRE will be open to the community.

The overall system of each EVI will be evaluated and compared to the state-of-the-art. This work will showcase the 5GNFIRE testbed capabilities and will point to future enhancements. The deployed hardware and the deployed scenarios will be the basis to construct and implement other EVIs using a different set of VxFs. This will enhance the 5GINFIRE VxF repository and will allow exploring various services and applications on each vertical.

The UGW or 5G In A Box has been deployed in two versions: PNF UGW and VNF UGW. The 5GinFIRE platform is going to provide the capabilities and functionalities of both (PNF and VNF UGW) for the new experimenters. Throughout the 5G In A Box the experimenter is enabled to explore different 5G use case using simultaneously WiFi and LTE networks.

Furthermore, the future work will also encompass the current EVIs maintenance and continuous integration with updates in the services provided by the 5GINFIRE portal and by the core MANO infrastructure. It is also expected that the experimentation conducted with current EVIs will highlight the need for new services on a virtuous cycle on the enhancement of the 5GINFIRE platform.

It is expected that the open calls will bring new experimenters, developers, and testbed providers. This will enable the exploitation of new use cases of the current EVIs by the new experimenters that will provide new scenarios. The new developers can design new VNFs and consequently new instances of the automotive and smart city EVIs and the creation of new verticals based on the current and new VNFs. Finally, an enhancement of the platform with new testbed providers will allow news uses of currents EVIs and VNFs.

Concerning to the FIRE integration, it is also expected that new testbed providers that are already in the FIRE ecosystem will exploit the current APIs of the 5GINFIRE portal to integrate FIRE based testbeds with 5GNFIRE. This can bring new integration requirements with 5GINFIRE that will be focus of the next actions. The integration with FIRE will also enable the scenarios to exploit current and new EVIs.

6 Conclusion

The 5GINFIRE project is establishing a NFV-enabled experimental testbed that will enable the instantiation and support vertical industries based on industry-leading and open source technologies focusing the next generation of Mobile Telecommunications Networks, a.k.a., 5G.

This document presented the overall components of the 5GINFIRE platform as an intermediate report on 5G testbed integration, as well as the initial vision of an EVI with guidelines for its deployment and instantiation.

Furthermore, the two EVIs that are being created inside the project that focuses the automotive and smart city verticals the roadmap to their further enhancements have been presented.

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